US010411644B2

(12) United States Patent
Sella et al.

(10) **Patent No.: US 10,411,644 B2**
(45) **Date of Patent: *Sep. 10, 2019**

(54) **ELECTRICALLY ISOLATED HEAT DISSIPATING JUNCTION BOX**

(71) Applicant: **Solaredge Technologies Ltd.**, Herzeliya (IL)

(72) Inventors: **Guy Sella**, Bitan Aharon (IL); **Lior Handelsman**, Givataim (IL); **Vadim Shmukler**, Rishon-Lezion (IL); **Meir Adest**, Raanana (IL); **Meir Gazit**, Ashkelon (IL); **Yoav Galin**, Raanana (IL)

(73) Assignee: **Solaredge Technologies, Ltd.**, Herzeliya (IL)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **15/651,134**

(22) Filed: **Jul. 17, 2017**

(65) **Prior Publication Data**

US 2018/0069505 A1 Mar. 8, 2018

Related U.S. Application Data

(63) Continuation of application No. 14/997,079, filed on Jan. 15, 2016, now Pat. No. 9,748,897, which is a

(Continued)

(51) **Int. Cl.**

H02S 40/34	(2014.01)
G08B 13/14	(2006.01)

(Continued)

(52) **U.S. Cl.**

CPC ***H02S 40/34*** (2014.12); ***G08B 13/1409*** (2013.01); ***H02G 15/10*** (2013.01);

(Continued)

(58) **Field of Classification Search**

CPC H02S 40/34; H02S 40/345; H02G 15/10; H05K 5/02; Y10T 29/49117

(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,369,210	A	2/1968	Manickella
3,596,229	A	7/1971	Hohorst

(Continued)

FOREIGN PATENT DOCUMENTS

CN	86200903	U	1/1987
CN	1236213	A	11/1999

(Continued)

OTHER PUBLICATIONS

Ciobotaru, et al., Control of single-stage single-phase PV inverter, Aug. 7, 2006.

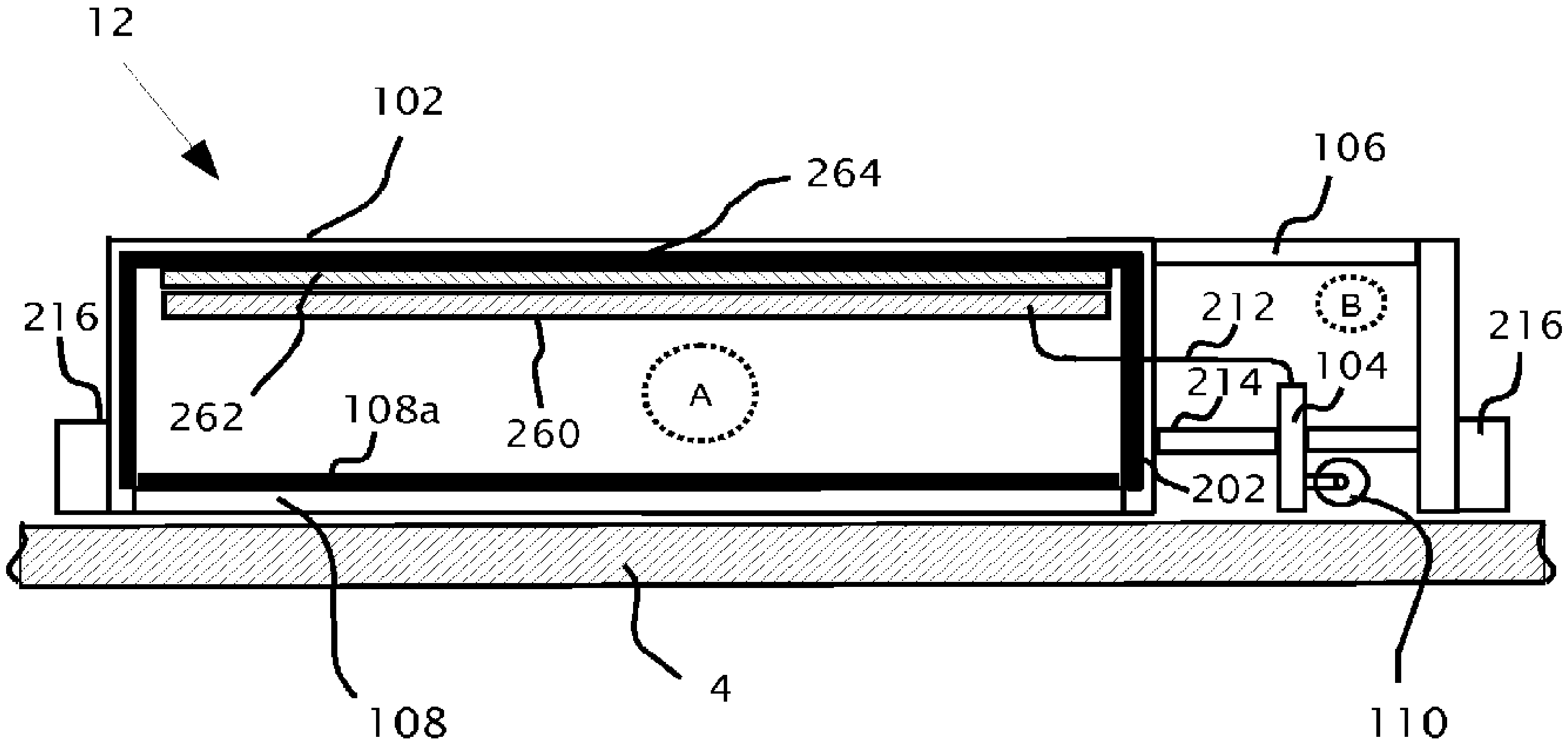
(Continued)

Primary Examiner — Dhiru R Patel
(74) *Attorney, Agent, or Firm* — Banner & Witcoff, Ltd.

(57) **ABSTRACT**

A junction box used for making electrical connections to a photovoltaic panel. The junction box has two chambers including a first chamber and a second chamber and a wall common to and separating both chambers. The wall may be adapted to have an electrical connection therethrough. The two lids are adapted to seal respectively the two chambers. The two lids are on opposite sides of the junction box relative to the photovoltaic panel. The two lids may be attachable using different sealing processes to a different level of hermeticity. The first chamber may be adapted to receive a circuit board for electrical power conversion. The junction box may include supports for mounting a printed circuit board in the first chamber. The second chamber is

(Continued)



configured for electrical connection to the photovoltaic panel. A metal heat sink may be bonded inside the first chamber.

18 Claims, 4 Drawing Sheets

Related U.S. Application Data

continuation of application No. 14/641,690, filed on Mar. 9, 2015, now Pat. No. 9,748,896, which is a continuation of application No. 13/901,706, filed on May 24, 2013, now Pat. No. 9,006,569, which is a continuation of application No. 12/785,773, filed on May 24, 2010, now Pat. No. 8,476,524.

(60) Provisional application No. 61/180,455, filed on May 22, 2009.

(51) **Int. Cl.**

H05K 5/02	(2006.01)
H05K 5/06	(2006.01)
H05K 7/20	(2006.01)
H05K 9/00	(2006.01)
H02G 15/10	(2006.01)

(52) **U.S. Cl.**
CPC ***H02S 40/345*** (2014.12); ***H05K 5/02*** (2013.01); ***H05K 5/062*** (2013.01); ***H05K 7/2039*** (2013.01); ***H05K 9/0007*** (2013.01); ***H05K 9/0009*** (2013.01); ***H05K 9/0015*** (2013.01); *Y10S 248/906* (2013.01); *Y10T 29/49117* (2015.01)

(58) **Field of Classification Search**
USPC 174/50
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,060,757	A		11/1977	McMurray	
4,101,816	A		7/1978	Shepter	
4,171,861	A		10/1979	Hohorst	
4,452,867	A		6/1984	Conforti	
4,460,232	A		7/1984	Sotolongo	
4,481,654	A		11/1984	Daniels et al.	
4,598,330	A		7/1986	Woodworth	
4,623,753	A		11/1986	Feldman et al.	
4,637,677	A		1/1987	Barkus	
4,641,042	A		2/1987	Miyazawa	
4,641,079	A		2/1987	Kato et al.	
4,644,458	A		2/1987	Harafuji et al.	
4,652,770	A		3/1987	Kumano	
4,783,728	A		11/1988	Hoffman	
RE33,057	E		9/1989	Clegg et al.	
4,868,379	A		9/1989	West	
4,888,063	A		12/1989	Powell	
4,888,702	A		12/1989	Gerken et al.	
4,899,269	A		2/1990	Rouzies	
4,945,559	A	*	7/1990	Collins	H02G 3/14 379/413
4,987,360	A		1/1991	Thompson	
5,045,988	A		9/1991	Gritter et al.	
5,081,558	A		1/1992	Mahler	
5,191,519	A		3/1993	Kawakami	
5,280,232	A		1/1994	Kohl et al.	
5,327,071	A		7/1994	Frederick et al.	
5,345,375	A		9/1994	Mohan	
5,391,235	A		2/1995	Inoue	
5,402,060	A		3/1995	Erisman	
5,446,645	A		8/1995	Shirahama et al.	
5,460,546	A		10/1995	Kunishi et al.	
5,493,154	A		2/1996	Smith et al.	
5,497,289	A		3/1996	Sugishima et al.	
5,517,378	A		5/1996	Asplund et al.	
5,548,504	A		8/1996	Takehara	
5,604,430	A		2/1997	Decker et al.	
5,616,913	A		4/1997	Litterst	
5,644,219	A		7/1997	Kurokawa	
5,646,501	A		7/1997	Fishman et al.	
5,659,465	A		8/1997	Flack et al.	
5,686,766	A		11/1997	Tamechika	
5,726,505	A		3/1998	Yamada et al.	
5,773,963	A		6/1998	Blanc et al.	
5,780,092	A		7/1998	Agbo et al.	
5,798,631	A		8/1998	Spee et al.	
5,801,519	A		9/1998	Midya et al.	
5,804,894	A		9/1998	Leeson et al.	
5,821,734	A		10/1998	Faulk	
5,822,186	A		10/1998	Bull et al.	
5,838,148	A		11/1998	Kurokami et al.	
5,869,956	A		2/1999	Nagao et al.	
5,873,738	A		2/1999	Shimada et al.	
5,892,354	A		4/1999	Nagao et al.	
5,905,645	A		5/1999	Cross	
5,919,314	A		7/1999	Kim	
5,923,158	A		7/1999	Kurokami et al.	
5,932,994	A		8/1999	Jo et al.	
5,945,806	A		8/1999	Faulk	
5,949,668	A		9/1999	Schweighofer	
5,963,010	A		10/1999	Hayashi et al.	
5,990,659	A		11/1999	Frannhagen	
6,031,736	A		2/2000	Takehara et al.	
6,038,148	A		3/2000	Farrington et al.	
6,046,919	A		4/2000	Madenokouji et al.	
6,050,779	A		4/2000	Nagao et al.	
6,078,511	A		6/2000	Fasullo et al.	
6,081,104	A		6/2000	Kern	
6,082,122	A		7/2000	Madenokouji et al.	
6,111,188	A		8/2000	Kurokami et al.	
6,111,391	A		8/2000	Cullen	
6,111,767	A		8/2000	Handleman	
6,163,086	A		12/2000	Choo	
6,166,455	A		12/2000	Li	
6,166,527	A		12/2000	Dwelley et al.	
6,169,678	B1		1/2001	Kondo et al.	
6,219,623	B1		4/2001	Wills	
6,255,360	B1		7/2001	Domschke et al.	
6,259,234	B1		7/2001	Perol	
6,262,558	B1		7/2001	Weinberg	
6,285,572	B1		9/2001	Onizuka et al.	
6,301,128	B1		10/2001	Jang et al.	
6,304,065	B1		10/2001	Wittenbreder	
6,320,769	B2		11/2001	Kurokami et al.	
6,339,538	B1		1/2002	Handleman	
6,344,612	B1		2/2002	Kuwahara et al.	
6,351,130	B1		2/2002	Preiser et al.	
6,369,462	B1		4/2002	Sin	
6,380,719	B2		4/2002	Underwood et al.	
6,396,170	B1		5/2002	Laufenberg et al.	
6,433,522	B1		8/2002	Sin	
6,448,489	B2		9/2002	Kimura et al.	
6,452,814	B1		9/2002	Wittenbreder	
6,493,246	B2		12/2002	Suzui et al.	
6,507,176	B2		1/2003	Wittenbreder, Jr.	
6,531,848	B1		3/2003	Chitsazan et al.	
6,545,211	B1		4/2003	Mimura	
6,548,205	B2		4/2003	Leung et al.	
6,590,793	B1		7/2003	Nagao et al.	
6,593,521	B2		7/2003	Kobayashi	
6,600,100	B2		7/2003	Ho et al.	
6,608,468	B2		8/2003	Nagase	
6,611,441	B2		8/2003	Kurokami et al.	
6,628,011	B2		9/2003	Droppo et al.	
6,650,560	B2		11/2003	MacDonald et al.	
6,653,549	B2		11/2003	Matsushita et al.	
6,655,987	B2		12/2003	Higashikozono et al.	
6,678,174	B2		1/2004	Suzui et al.	
6,690,590	B2		2/2004	Stamenic et al.	
6,738,692	B2		5/2004	Schienbein et al.	

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,765,315	B2	7/2004	Hammerstrom et al.
6,768,047	B2	7/2004	Chang et al.
6,788,033	B2	9/2004	Vinciarelli
6,795,318	B2	9/2004	Haas et al.
6,801,442	B2	10/2004	Suzui et al.
6,828,503	B2	12/2004	Yoshikawa et al.
6,850,074	B2	2/2005	Adams et al.
6,882,131	B1	4/2005	Takada et al.
6,914,418	B2	7/2005	Sung
6,919,714	B2	7/2005	Delepaut
6,927,955	B2	8/2005	Suzui et al.
6,933,627	B2	8/2005	Wilhelm
6,936,995	B2	8/2005	Kapsokavathis et al.
6,950,323	B2	9/2005	Achleitner et al.
6,963,147	B2	11/2005	Kurokami et al.
6,984,967	B2	1/2006	Notman
6,984,970	B2	1/2006	Capel
7,030,597	B2	4/2006	Bruno et al.
7,031,176	B2	4/2006	Kotsopoulos et al.
7,042,195	B2	5/2006	Tsunetsugu et al.
7,046,531	B2	5/2006	Zocchi et al.
7,053,506	B2	5/2006	Alonso et al.
7,072,194	B2	7/2006	Nayar et al.
7,079,406	B2	7/2006	Kurokami et al.
7,087,332	B2	8/2006	Harris
7,090,509	B1	8/2006	Gilliland et al.
7,091,707	B2	8/2006	Cutler
7,097,516	B2	8/2006	Werner et al.
7,126,053	B2	10/2006	Kurokami et al.
7,126,294	B2	10/2006	Minami et al.
7,138,786	B2	11/2006	Ishigaki et al.
7,148,669	B2	12/2006	Maksimovic et al.
7,154,755	B2	12/2006	Araujo
7,158,359	B2	1/2007	Bertele et al.
7,158,395	B2	1/2007	Deng et al.
7,174,973	B1	2/2007	Lysaght
7,193,872	B2	3/2007	Siri
7,218,541	B2	5/2007	Price et al.
7,248,946	B2	7/2007	Bashaw et al.
7,256,566	B2	8/2007	Bhavaraju et al.
7,277,304	B2	10/2007	Stancu et al.
7,282,814	B2	10/2007	Jacobs
7,291,036	B1	11/2007	Daily et al.
RE39,976	E	1/2008	Schiff et al.
7,336,056	B1	2/2008	Dening
7,352,154	B2	4/2008	Cook
7,371,963	B2	5/2008	Suenaga et al.
7,372,712	B2	5/2008	Stancu et al.
7,385,380	B2	6/2008	Ishigaki et al.
7,385,833	B2	6/2008	Keung
7,394,237	B2	7/2008	Chou et al.
7,420,815	B2	9/2008	Love
7,471,014	B2	12/2008	Lum et al.
7,589,437	B2	9/2009	Henne et al.
7,622,802	B2	11/2009	Paulus et al.
7,646,116	B2	1/2010	Batarseh et al.
7,719,140	B2	5/2010	Ledenev et al.
7,759,575	B2	7/2010	Jones et al.
7,763,807	B2	7/2010	Richter
7,772,716	B2	8/2010	Shaver, II et al.
7,782,031	B2	8/2010	Qiu et al.
7,787,273	B2	8/2010	Lu et al.
7,804,282	B2	9/2010	Bertele
7,812,701	B2	10/2010	Lee et al.
7,824,189	B1	11/2010	Lauermann et al.
7,868,599	B2	1/2011	Rahman et al.
7,880,334	B2	2/2011	Evans et al.
7,893,346	B2	2/2011	Nachamkin et al.
7,948,221	B2	5/2011	Watanabe et al.
7,952,897	B2	5/2011	Nocentini et al.
7,960,650	B2	6/2011	Richter et al.
8,003,885	B2	8/2011	Richter et al.
8,035,249	B2	10/2011	Shaver, II et al.
8,097,818	B2	1/2012	Gerull et al.
8,204,709	B2	6/2012	Presher, Jr. et al.
8,222,533	B2	7/2012	Gherardini et al.
8,248,804	B2	8/2012	Han et al.
8,289,183	B1	10/2012	Foss
8,294,451	B2	10/2012	Hasenfus
8,303,349	B2 *	11/2012	Shmukler H01R 13/2435 439/724
8,324,921	B2	12/2012	Adest et al.
8,378,656	B2	2/2013	de Rooij et al.
8,410,950	B2	4/2013	Takehara et al.
8,427,009	B2	4/2013	Shaver, II et al.
8,710,351	B2	4/2014	Robbins
8,785,771	B2	7/2014	Dunkleberger et al.
8,816,535	B2	8/2014	Adest et al.
8,823,218	B2	9/2014	Hadar et al.
8,835,748	B2	9/2014	Frolov et al.
8,878,563	B2	11/2014	Robbins
8,963,375	B2	2/2015	DeGraaff
2002/0044473	A1	4/2002	Toyomura et al.
2002/0056089	A1	5/2002	Houston
2003/0058593	A1	3/2003	Bertele et al.
2003/0066076	A1	4/2003	Minahan
2003/0075211	A1	4/2003	Makita et al.
2003/0080741	A1	5/2003	LeRow et al.
2003/0214274	A1	11/2003	Lethellier
2004/0041548	A1	3/2004	Perry
2004/0125618	A1	7/2004	De Rooij et al.
2004/0140719	A1	7/2004	Vulih et al.
2004/0169499	A1	9/2004	Huang et al.
2004/0201279	A1	10/2004	Templeton
2004/0201933	A1	10/2004	Blanc
2004/0246226	A1	12/2004	Moon
2005/0002214	A1	1/2005	Deng et al.
2005/0005785	A1	1/2005	Poss et al.
2005/0017697	A1	1/2005	Capel
2005/0057214	A1	3/2005	Matan
2005/0057215	A1	3/2005	Matan
2005/0068820	A1	3/2005	Radosevich et al.
2005/0099138	A1	5/2005	Wilhelm
2005/0103376	A1	5/2005	Matsushita et al.
2005/0162018	A1	7/2005	Realmuto et al.
2005/0172995	A1	8/2005	Rohrig et al.
2005/0226017	A1	10/2005	Kotsopoulos et al.
2006/0001406	A1	1/2006	Matan
2006/0017327	A1	1/2006	Siri et al.
2006/0034106	A1	2/2006	Johnson
2006/0038692	A1	2/2006	Schnetker
2006/0053447	A1	3/2006	Krzyzanowski et al.
2006/0068239	A1	3/2006	Norimatsu et al.
2006/0108979	A1	5/2006	Daniel et al.
2006/0113843	A1	6/2006	Beveridge
2006/0113979	A1	6/2006	Ishigaki et al.
2006/0118162	A1	6/2006	Saelzer et al.
2006/0132102	A1	6/2006	Harvey
2006/0149396	A1	7/2006	Templeton
2006/0162772	A1	7/2006	Presher et al.
2006/0163946	A1	7/2006	Henne et al.
2006/0171182	A1	8/2006	Siri et al.
2006/0174939	A1	8/2006	Matan
2006/0185727	A1	8/2006	Matan
2006/0192540	A1	8/2006	Balakrishnan et al.
2006/0208660	A1	9/2006	Shinmura et al.
2006/0227578	A1	10/2006	Datta et al.
2006/0235717	A1	10/2006	Sharma et al.
2006/0237058	A1	10/2006	McClintock et al.
2007/0044837	A1	3/2007	Simburger et al.
2007/0075711	A1	4/2007	Blanc et al.
2007/0081364	A1	4/2007	Andreycak
2007/0159866	A1	7/2007	Siri
2007/0164750	A1	7/2007	Chen et al.
2007/0165347	A1	7/2007	Wendt et al.
2007/0205778	A1	9/2007	Fabbro et al.
2007/0227574	A1	10/2007	Cart
2007/0236187	A1	10/2007	Wai et al.
2007/0273342	A1	11/2007	Kataoka et al.
2008/0024098	A1	1/2008	Hojo
2008/0088184	A1	4/2008	Tung et al.
2008/0097655	A1	4/2008	Hadar et al.
2008/0106250	A1	5/2008	Prior et al.
2008/0142071	A1	6/2008	Dorn et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2008/0143188	A1	6/2008	Adest et al.
2008/0143462	A1	6/2008	Belisle et al.
2008/0147335	A1	6/2008	Adest et al.
2008/0150366	A1	6/2008	Adest et al.
2008/0179949	A1	7/2008	Besser et al.
2008/0236647	A1	10/2008	Gibson et al.
2008/0236648	A1	10/2008	Klein et al.
2008/0238195	A1	10/2008	Shaver et al.
2008/0246460	A1	10/2008	Smith
2008/0246463	A1	10/2008	Sinton et al.
2008/0291609	A1	11/2008	Victor et al.
2009/0073726	A1	3/2009	Babcock
2009/0084570	A1	4/2009	Gherardini et al.
2009/0097172	A1	4/2009	Bremicker et al.
2009/0102440	A1	4/2009	Coles
2009/0141522	A1	6/2009	Adest et al.
2009/0182532	A1	7/2009	Stoeber et al.
2009/0190275	A1	7/2009	Gilmore et al.
2009/0242011	A1	10/2009	Proisy et al.
2009/0283129	A1	11/2009	Foss
2009/0325003	A1	12/2009	Aberle et al.
2010/0020576	A1	1/2010	Falk
2010/0071742	A1	3/2010	de Rooij et al.
2010/0124087	A1	5/2010	Falk
2010/0139743	A1	6/2010	Hadar et al.
2010/0154858	A1	6/2010	Jain
2010/0206378	A1	8/2010	Erickson, Jr. et al.
2010/0214808	A1	8/2010	Rodriguez
2010/0241375	A1	9/2010	Kumar et al.
2010/0244575	A1	9/2010	Coccia et al.
2010/0301991	A1	12/2010	Sella et al.
2011/0006743	A1	1/2011	Fabbro
2011/0043172	A1	2/2011	Dearn
2011/0068633	A1	3/2011	Quardt et al.
2011/0108087	A1	5/2011	Croft et al.
2011/0125431	A1	5/2011	Adest et al.
2011/0133552	A1	6/2011	Binder et al.
2011/0198935	A1	8/2011	Hinman et al.
2011/0240100	A1	10/2011	Lu et al.
2011/0254372	A1	10/2011	Haines et al.
2011/0267859	A1	11/2011	Chapman
2011/0290317	A1	12/2011	Naumovitz et al.
2012/0043818	A1	2/2012	Stratakos et al.
2012/0080943	A1	4/2012	Phadke
2012/0138123	A1	6/2012	Newdoll et al.
2012/0139343	A1	6/2012	Adest et al.
2012/0194003	A1	8/2012	Schmidt et al.
2012/0199172	A1	8/2012	Avrutsky
2013/0038124	A1	2/2013	Newdoll et al.
2013/0049710	A1	2/2013	Kraft et al.
2013/0082724	A1	4/2013	Noda et al.
2013/0321013	A1	12/2013	Pisklak et al.

FOREIGN PATENT DOCUMENTS

CN	1577980	A	2/2005
CN	1578034	A	2/2005
CN	1700480	A	11/2005
CN	1933315	A	3/2007
CN	200941388	Y	8/2007
CN	101192744	A	6/2008
CN	101388530	A	3/2009
CN	201207557	Y	3/2009
CN	201238275	Y	5/2009
CN	101951190	A	1/2011
CN	101953051	A	1/2011
DE	19737286	A1	3/1999
DE	10219956	A1	4/2003
DE	102004053942	A1	5/2006
DE	102005036153	A1	12/2006
DE	102005030907	A1	1/2007
DE	102007051134	A1	3/2009
DE	102007037130	B3	4/2009
DE	202009007318	U1	8/2009
DE	102008057874	A1	5/2010
DE	102009051186	A1	5/2010
DE	102009022569	A1	12/2010
EP	419093	A2	3/1991
EP	420295	A1	4/1991
EP	604777	A1	7/1994
EP	756178	A2	1/1997
EP	827254	A2	3/1998
EP	1039361	A1	9/2000
EP	1330009	A2	7/2003
EP	1503490	A1	2/2005
EP	1531545	A2	5/2005
EP	1657557	A1	5/2006
EP	1657797	A1	5/2006
EP	1887675	A2	2/2008
EP	2048679	A1	4/2009
EP	2130286	A1	12/2009
EP	2135296	A2	12/2009
EP	2256819	A1	12/2010
ES	2249147	A1	3/2006
ES	2249149	A1	3/2006
GB	2128017	A	4/1984
GB	2480015	A	11/2011
JP	61065320	A	4/1986
JP	H10308523	A	11/1998
JP	11041832	A	2/1999
JP	11103538	A	4/1999
JP	2003124492	A	4/2003
JP	2003134667	A	5/2003
JP	2003282916	A	10/2003
JP	2006278755	A	10/2006
JP	2007058845	A	3/2007
JP	4174227	B2	10/2008
TW	200913291	A	3/2009
WO	1993013587	A1	7/1993
WO	1996013093	A1	5/1996
WO	1998023021	A2	5/1998
WO	00/00839	A1	1/2000
WO	00/21178	A1	4/2000
WO	0075947		12/2000
WO	0231517		4/2002
WO	2003050938	A2	6/2003
WO	2003071655	A1	8/2003
WO	2003098703		11/2003
WO	2004023278	A2	3/2004
WO	2004090993	A2	10/2004
WO	2004107543	A2	12/2004
WO	2005076444	A1	8/2005
WO	2005076445	A1	8/2005
WO	2006005125	A1	1/2006
WO	2006007198	A1	1/2006
WO	2006/074561	A1	7/2006
WO	2006071436	A2	7/2006
WO	2006078685	A2	7/2006
WO	2007006564	A2	1/2007
WO	2007048421	A2	5/2007
WO	2007073951	A1	7/2007
WO	2007084196	A2	7/2007
WO	2007090476	A2	8/2007
WO	2007113358	A1	10/2007
WO	2008119034	A1	10/2008
WO	2008121266	A2	10/2008
WO	2008125915	A2	10/2008
WO	2008132551	A2	11/2008
WO	2008132553	A2	11/2008
WO	2009011780	A2	1/2009
WO	2009051870	A1	4/2009
WO	2009073868	A1	6/2009
WO	2009118682	A2	10/2009
WO	2009118683	A2	10/2009
WO	2009136358	A1	11/2009
WO	2010065043	A1	6/2010
WO	2010065388	A1	6/2010
WO	2010072717	A1	7/2010
WO	2010078303	A2	7/2010
WO	20100134057	A1	11/2010
WO	2011011711	A2	1/2011

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

WO	2011017721 A1	2/2011
WO	2011023732 A2	3/2011

OTHER PUBLICATIONS

International Search Report and Written Opinion for PCT/IB2007/004591 dated Jul. 5, 2010.
European Communication for EP07873361.5 dated Jul. 12, 2010.
European Communication for EP07874022.2 dated Oct. 18, 2010.
European Communication for EP07875148.4 dated Oct. 18, 2010.
Chen, et al., "A New Low-Stress Buck-Boost Converter for Universal-Input PFC Applications", IEEE Applied Power Electronics Conference, Feb. 2001, Colorado Power Electronics Center Publications.
Chen, et al., "Buck-Boost PWM Converters Having Two Independently Controlled Switches", IEEE Power Electronics Specialists Conference, Jun. 2001, Colorado Power Electronics Center Publications.
Esram, et al., "Comparison of Photovoltaic Array Maximum Power Point Tracking Techniques", IEEE Transactions on Energy Conversion, vol. 22, No. 2, Jun. 2007, pp. 439-449.
Walker, et al., "Photovoltaic DC-DC Module Integrated Converter for Novel Cascaded and Bypass Grid Connection Topologies-Design and Optimisation", 37th IEEE Power Electronics Specialists Conference, Jun. 18-22, 2006, Jeju, Korea.
Geoffrey R. Walker Affidavit re: U.S. Appl. No. 11/950,307.
Geoffrey R. Walker Affidavit re: U.S. Appl. No. 11/950,271.
International Search Report for PCT/IB2007/004610 dated Feb. 23, 2009.
International Search Report for PCT/IB2007/004584 dated Jan. 28, 2009.
International Search Report for PCT/IB2007/004586 dated Mar. 5, 2009.
International Search Report for PCT/IB2007/004643 dated Jan. 30, 2009.
International Search Report for PCT/US2008/085736 dated Jan. 28, 2009.
International Search Report for PCT/US2008/085754 dated Feb. 9, 2009.
International Search Report for PCT/US2008/085755 dated Feb. 3, 2009.
Kajihara, et al., "Model of Photovoltaic Cell Circuits Under Partial Shading", 2005 IEEE, pp. 866-870.
Knaupp, et al., "Operation of a 10 KW PV Fagade with 100 W AC Photovoltaic Modules", 1996 IEEE, 25th PVSC, May 13-17, 1996, pp. 1235-1238, Washington, DC.
Alonso, et al., "Cascaded H-Bridge Multilevel Converter for Grid Connected Photovoltaic Generators with Independent Maximum Power Point Tracking of Each Solor Array", 2003 IEEE 34th, Annual Power Electronics Specialists Conference, Acapulco, Mexico, Jun. 15-19, 2003, pp. 731-735, vol. 2.
Myrzik, et al., "String and Module Integrated Inverters for Single-Phase Grid Connected Photovoltaic Systems—A Review", Power Tech Conference Proceedings, 2003 IEEE Bologna, Jun. 23-26, 2003, p. 8, vol. 2.
Chen, et al., "Predictive Digital Current Programmed Control", IEEE Transactions on Power Electronics, vol. 18, Issue 1, Jan. 2003.
Wallace, et al., "DSP Controlled Buck/Boost Power Factor Correction for Telephony Rectifiers", Telecommunications Energy Conference 2001, INTELEC 2001, Twenty-Third International, Oct. 18, 2001, pp. 132-138.
Alonso, "A New Distributed Converter Interface for PV Panels", 20th European Photovoltaic Solar Energy Conference, Jun. 6-10, 2005, Barcelona, Spain, pp. 2288-2291.
Alonso, "Experimental Results of Intelligent PV Module for Grid-Connected PV Systems", 21st European Photovoltaic Solar Energy Conference, Sep. 4-8, 2006, Dresden, Germany, pp. 2297-2300.
Enslin, "Integrated Photovoltaic Maximum Power Point Tracking Converter", IEEE Transactions on Industrial Electronics, vol. 44, No. 6, Dec. 1997, pp. 769-773.
Sep. 7-9, 1999—Lindgren, "Topology for Decentralised Solar Energy Inverters with a Low Voltage AC-Bus", Chalmers University of Technology, Department of Electrical Power Engineering, EPE '99—Lausanne.
Nikraz, "Digital Control of a Voltage Source Inverter in a Photovoltaic Applications", 2004 35th Annual IEEE Power Electronics Specialists Conference, Aachen, Germany, 2004, pp. 3266-3271.
Orduz, "Evaluation Test Results of a New Distributed MPPT Converter", 22nd European Photovoltaic Solar Energy Conference, Sep. 3-7, 2007, Milan, Italy.
Palma, "A Modular Fuel Cell, Modular DC-DC Converter Concept for High Performance and Enhanced Reliability", IEEE 2007, pp. 2633-2638.
Sep. 16-19, 1996—Quaschning, "Cost Effectiveness of Shadow Tolerant Photovoltaic Systems", Berlin University of Technology, Institute of Electrical Energy Technology, Renewable Energy Section. EuroSun '96, pp. 819-824.
Roman, "Intelligent PV Module for Grid-Connected PV Systems", IEEE Transactions on Industrial Electronics, vol. 52, No. 4, Aug. 2006, pp. 1066-1073.
Roman, "Power Line Communications in Modular PV Systems", 20th European Photovoltaic Solar Energy Conference, Jun. 6-10, 2005, Barcelona, Spain, pp. 2249-2252.
Uriarte, "Energy Integrated Management System for PV Applications", 20th European Photovoltaic Solar Energy Conference, Jun. 6-10, 2005, Barcelona, Spain, pp. 2292-2295.
Walker, "Cascaded DC-DC Converter Connection of Photovoltaic Modules", IEEE Transactions on Power Electronics, vol. 19, No. 4, Jul. 2004, pp. 1130-1139.
Oct. 3-7, 1999—Matsui, et al., "A New Maximum Photovoltaic Power Tracking Control Scheme Based on Power Equilibrium at DC Link", IEEE, 1999, pp. 804-809.
Hou, et al., Application of Adaptive Algorithm of Solar Cell Battery Charger, Apr. 2004.
Stamenic, et al., "Maximum Power Point Tracking for Building Integrated Photovoltaic Ventilation Systems", 2000.
International Preliminary Report on Patentability for PCT/IB2008/055092 dated Jun. 8, 2010.
International Search Report for PCT/IB2008/055092 dated Sep. 8, 2009.
Walker, "Cascaded DC-DC Converter Connection of Photovoltaic Modules", 33rd Annual IEEE Power Electronics Specialists Conference. PESC 2002. Conference Proceedings. CAIRNS, Queensland, Australia, Jun. 23-27, 2002; [Annual Power Electronics Specialists Conference], New York, NY: IEEE US, vol. 1, Jun. 23, 2002, pp. 24-29, XP010596060 ISBN: 978-0-7803-7262-7, figure 1.
International Search Report and Opinion of International Patent Application WO2009136358 (PCT/IB2009/051831), dated Sep. 16, 2009.
Informal Comments to the International Search Report dated Dec. 3, 2009.
PCT/IB2010/052287 International Search Report and Written Opinion dated Sep. 2, 2010.
UK Intellectual Property office, Combined Search and Examination Report for GB1100450.4 under Sections 17 and 18 (3), Jul. 14, 2011.
Jain, et al., "A Single-Stage Grid Connected Inverter Topology for Solar PV Systems with Maximum Power Point Tracking", IEEE Transactions on Power Electronics, vol. 22, No. 5, Sep. 2007, pp. 1928-1940.
Lynch, et al., "Flexible DER Utility Interface System: Final Report", Sep. 2004-May 2006, Northern Power Systems, Inc., Waitsfield, Vermont B. Kroposki, et al., National Renewable Energy Laboratory Golden, Colorado Technical Report NREL/TP-560-39876, Aug. 2006.
Schimpf, et al., "Grid Connected Converters for Photovoltaic, State of the Art, Ideas for improvement of Transformerless Inverters", NORPIE/2008, Nordic Workshop on Power and Industrial Electronics, Jun. 9-11, 2008.

(56) **References Cited**

OTHER PUBLICATIONS

Sandia Report SAND96-2797 I UC-1290 Unlimited Release, Printed Dec. 1996, "Photovoltaic Power Systems and the National Electrical Code: Suggested Practices", by John Wiles, Southwest Technology Development Institute New Mexico State University Las Cruces, NM.
United Kingdom Intellectual Property Office, Combined Search and Examination Report Under Sections 17 and 18(3), GB1020862.7, dated Jun. 16, 2011.
QT Technical Application Papers, "ABB Circuit-Breakers for Direct current Applications", ABB SACE S.p.A., An ABB Group Coupany, L.V. Breakers, Via Baioni, 35, 24123 Bergamo—Italy, Tel.: +39 035.395.111—Telefax: +39 035.395.306-433.
Woyte, et al., "Mains Monitoring and Protection in a European Context", 17th European Photovoltaic Solar Energy Conference and Exhibition, Munich, Germany, Oct. 22-26, 2001, Achim, Woyte, et al., pp. 1-4.
"Implementation and testing of Anti-Islanding Algorithms for IEEE 929-2000 Compliance of Single Phase Photovoltaic Inverters", Raymond M. Hudson, Photovoltaic Specialists Conference, 2002. Conference Record of the Twenty-Ninth IEEE, May 19-24, 2002.
Frairchild Semiconductor, Application Note 9016, IGBT Basics 1, by K.S. OH Feb. 1, 2001.
"Disconnect Switches in Photovoltaic Applications", ABB, Inc., Low Voltage Control Products & Systems, 1206 Hatton Road, Wichita Falls, TX 86302, Phone 888-385-1221, 940-397-7000, Fax: 940-397-7085, 1SXU301197130201, Nov. 2009.
Walker, "A DC Circuit Breaker for an Electric Vehicle Battery Pack", Australasian Universities Power Engineering Conference and IEAust Electric Energy Conference, Sep. 26-29, 1999.
Combined Search and Examination Report for GB1018872.0 dated Apr. 15, 2011, 2 pages.
Baggio, "Quasi-ZVS Activity Auxiliary Commutation Circuit for Two Switches Forward Converter", 32nd Annual IEEE Power Electronics Specialists Conference. PESC 2001. Conference Proceedings. Vancouver, Canada, Jun. 17-21, 2001; [Annual Power Electronics Specialists Conference] New York, NY: IEEE, US.
Ilic, "Interleaved Zero-Current-Transition Buck Converter", IEEE Transactions on Industry Applications, IEEE Service Center, Piscataway, NJ, US, vol. 43, No. 6, Nov. 1, 2007, pp. 1619-1627, XP011197477 ISSN: 0093-9994, pp. 1619-1922.
Lee: "Novel Zero-Voltage-Transition and Zero-Current-Transition Pulse-Width-Modulation Converters", Power Electronics Specialists Conference, 1997, PESC '97, Record, 28th Annual IEEE St. Louis, MO, USA, Jun. 22-27, 1997, New York, NY, USA IEEE, US, vol. 1, Jun. 22, 1997, pp. 233-239, XP010241553, ISBN: 978-0-7803-3840-1, pp. 233-236.
International Search Report and Opinion of International Patent Application PCT/2009/051221, dated Oct. 19, 2009.
Sakamoto, "Switched Snubber for High-Frequency Switching Converters", Electronics & Communications in Japan, Part 1—Communications, Wiley, Hoboken, NJ, US, vol. 76, No. 2, Feb. 1, 1993, pp. 30-38, XP000403018 ISSN: 8756-6621, pp. 30-35.
Duarte, "A Family of ZVX-PWM Active-Clamping DC-to-DC Converters: Synthesis, Analysis and Experimentation", Telecommunications Energy Conference, 1995, INTELEC '95, 17th International the Hague, Netherlands, Oct. 29-Nov. 1, 1995, New York, NY, US, IEEE, US, Oct. 29, 1995, pp. 502-509, XP010161283 ISBN: 978-0-7803-2750-4 p. 503-504.
International Search Report and Opinion of International Patent Application PCT/2009/051222, dated Oct. 7, 2009.
Communication in EP07874025.5 dated Aug. 17, 2011.
IPRP for PCT/IB2008/055095 dated Jun. 8, 2010, with Written Opinion.
ISR for PCT/IB2008/055095 dated Apr. 30, 2009.
IPRP for PCT/IL2007/001064 dated Mar. 17, 2009, with Written Opinion dated Mar. 25, 2008.
ISR for PCT/IL07/01064 dated Mar. 25, 2008.
IPRP for PCT/IB2007/004584 dated Jun. 10, 2009, with Written Opinion.
IPRP for PCT/IB2007/004586 dated Jun. 10, 2009, with Written Opinion.
IPRP for PCT/IB2007/004591 dated Jul. 13, 2010, with Written Opinion.
IPRP for PCT/IB2007/004610 dated Jun. 10, 2009, with Written Opinion.
IPRP for PCT/IB2007/004643 dated Jun. 10, 2009, with Written Opinion.
Written Opinion for PCT/IB2008/055092 submitted with IPRP dated Jun. 8, 2010.
IPRP for PCT/US2008/085754 dated Jun. 8, 2010, with Written Opinion dated Jan. 21, 2009.
IPRP for PCT/US2008/085755 dated Jun. 8, 2010, with Written Opinion dated Jan. 20, 2009.
IPRP for PCT/IB2009/051221 dated Sep. 28, 2010, with Written Opinion.
IPRP for PCT/IB2009/051222 dated Sep. 28, 2010, with Written Opinion.
IPRP for PCT/IB2009/051831 dated Nov. 9, 2010, with Written Opinion.
IPRP for PCT/US2008/085736 dated Jun. 7, 2011, with Written Opinion.
IPRP for PCT/IB2010/052287 dated Nov. 22, 2011, with Written Opinion.
ISR for PCT/IB2010/052413 dated Sep. 7, 2010.
UK Intellectual Property Office, Application No. GB1109618.7, Patents Act 1977, Examination Report Under Section. 18(3), Sep. 16, 2011.
UK Intellectual Property Office, Patents Act 1977: Patents Rules Notification of Grant: Patent Serial No. GB2480015, Nov. 29, 2011.
Chinese Office Action—CN Appl. 201410347742.1—dated Nov. 12, 2015.

* cited by examiner

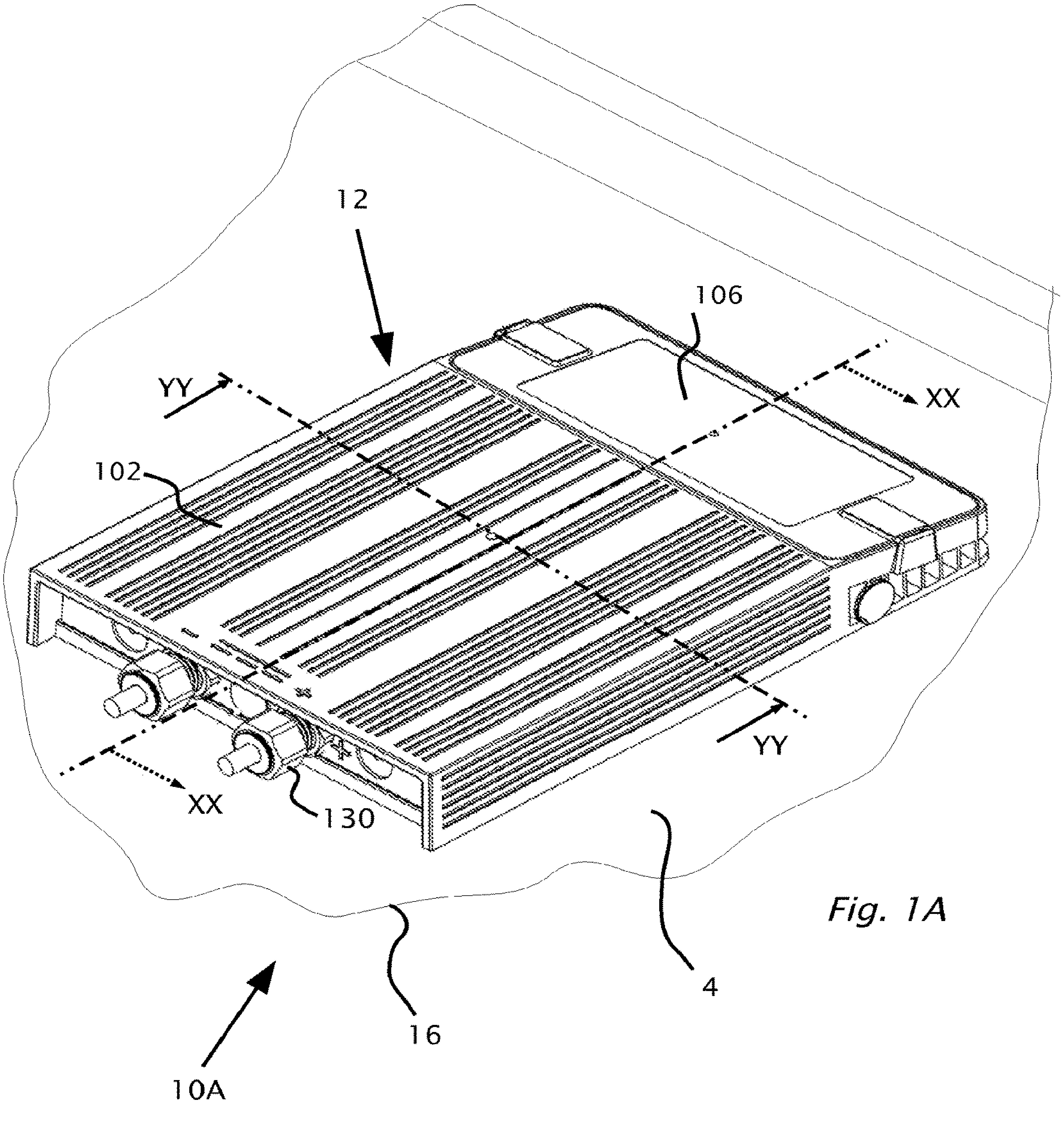


Fig. 1A

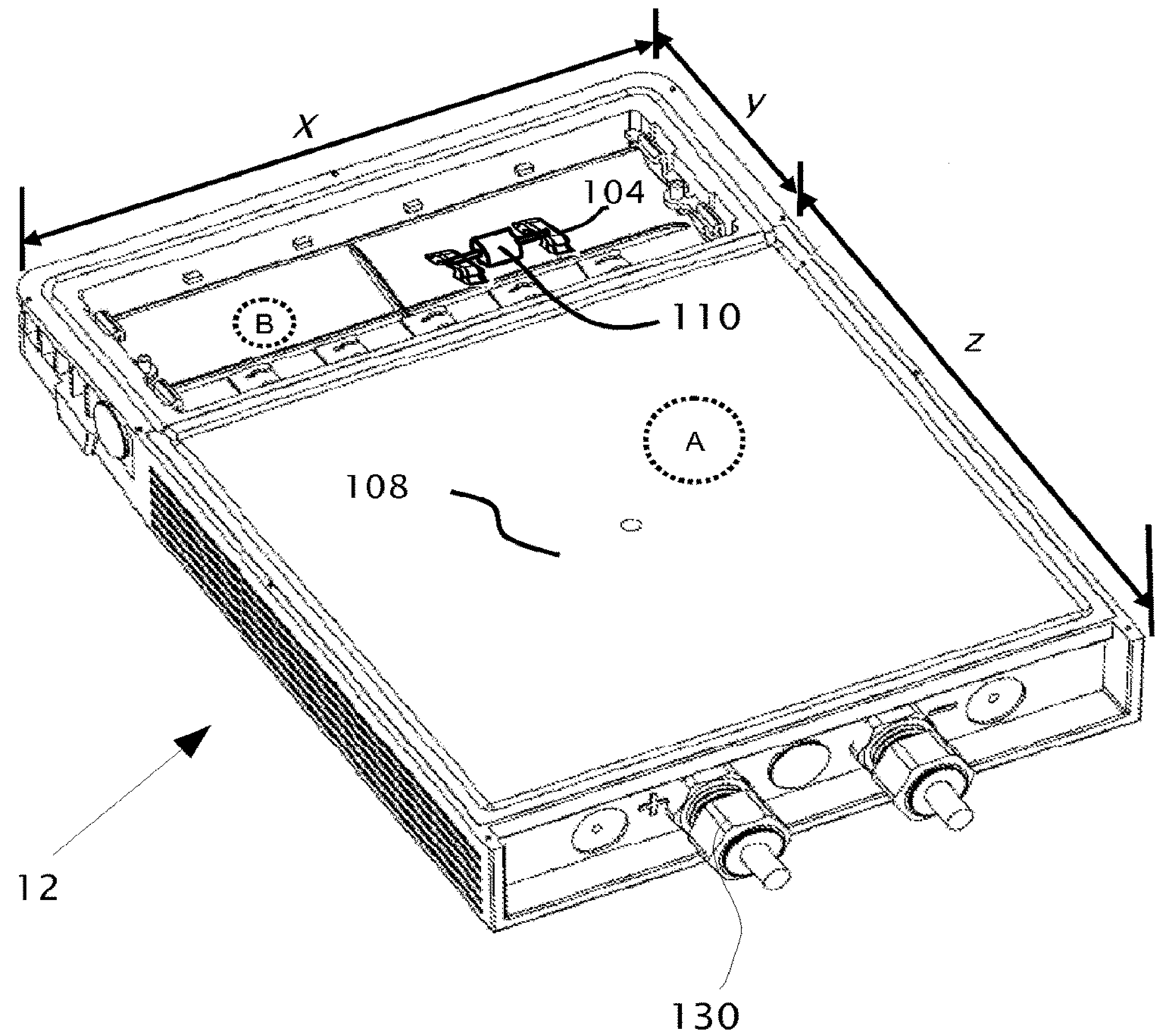


Fig. 1B

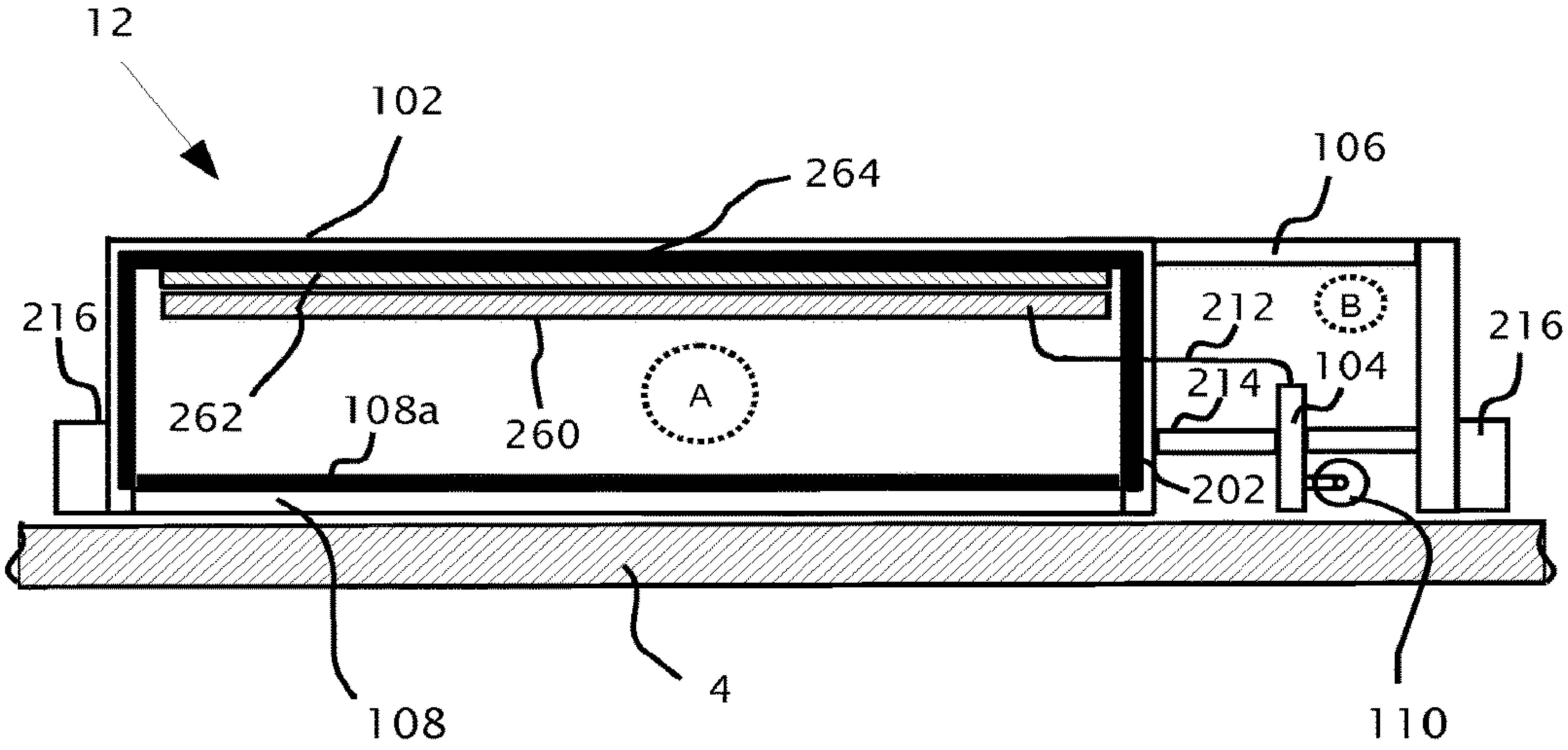

12
102
264
106
216
212
B
216
214
104
262
108a
260
A
202
108
4
110

Fig. 2A

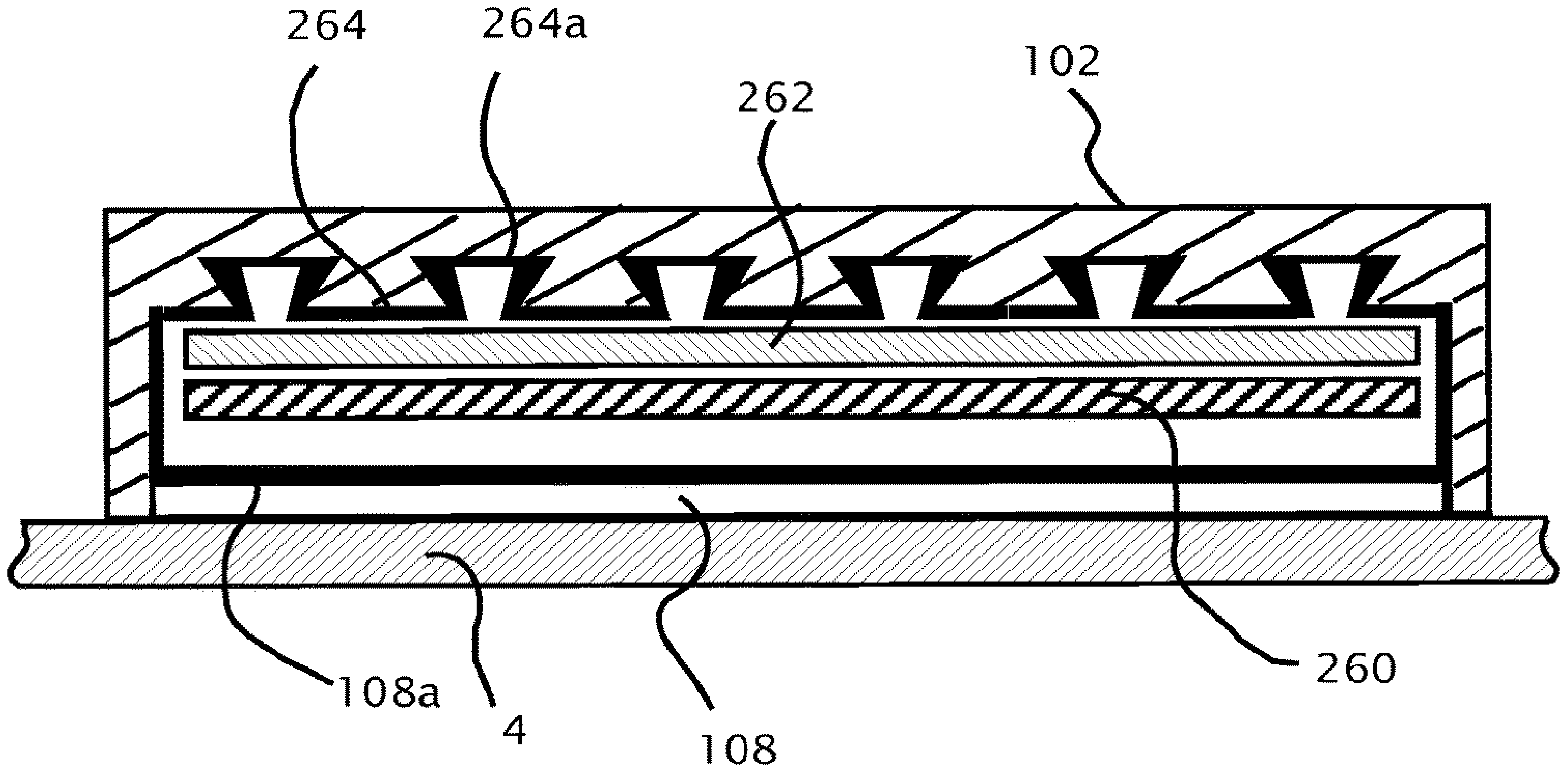

264
264a
102
262
260
108a
4
108

Fig. 2B

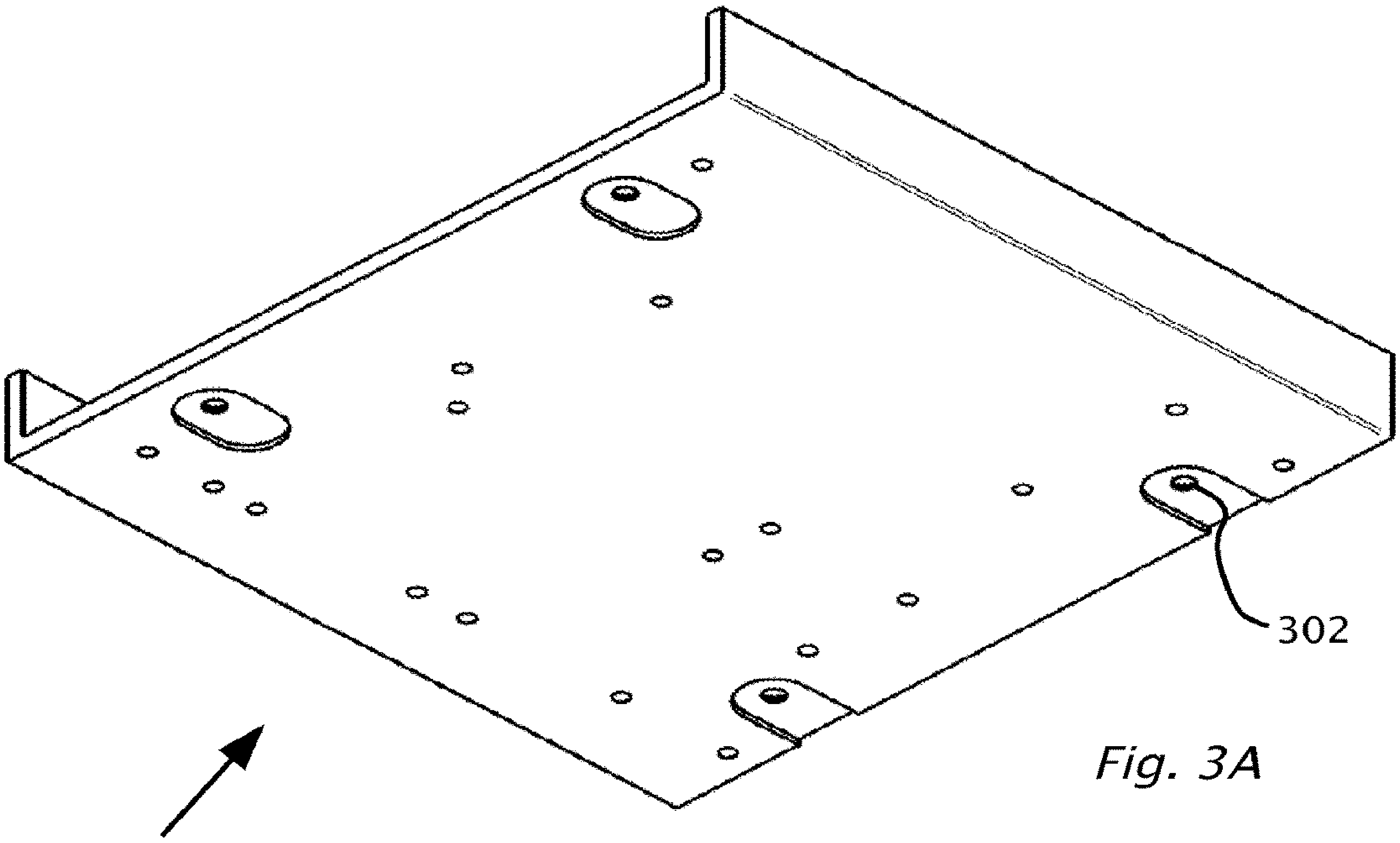


Fig. 3A

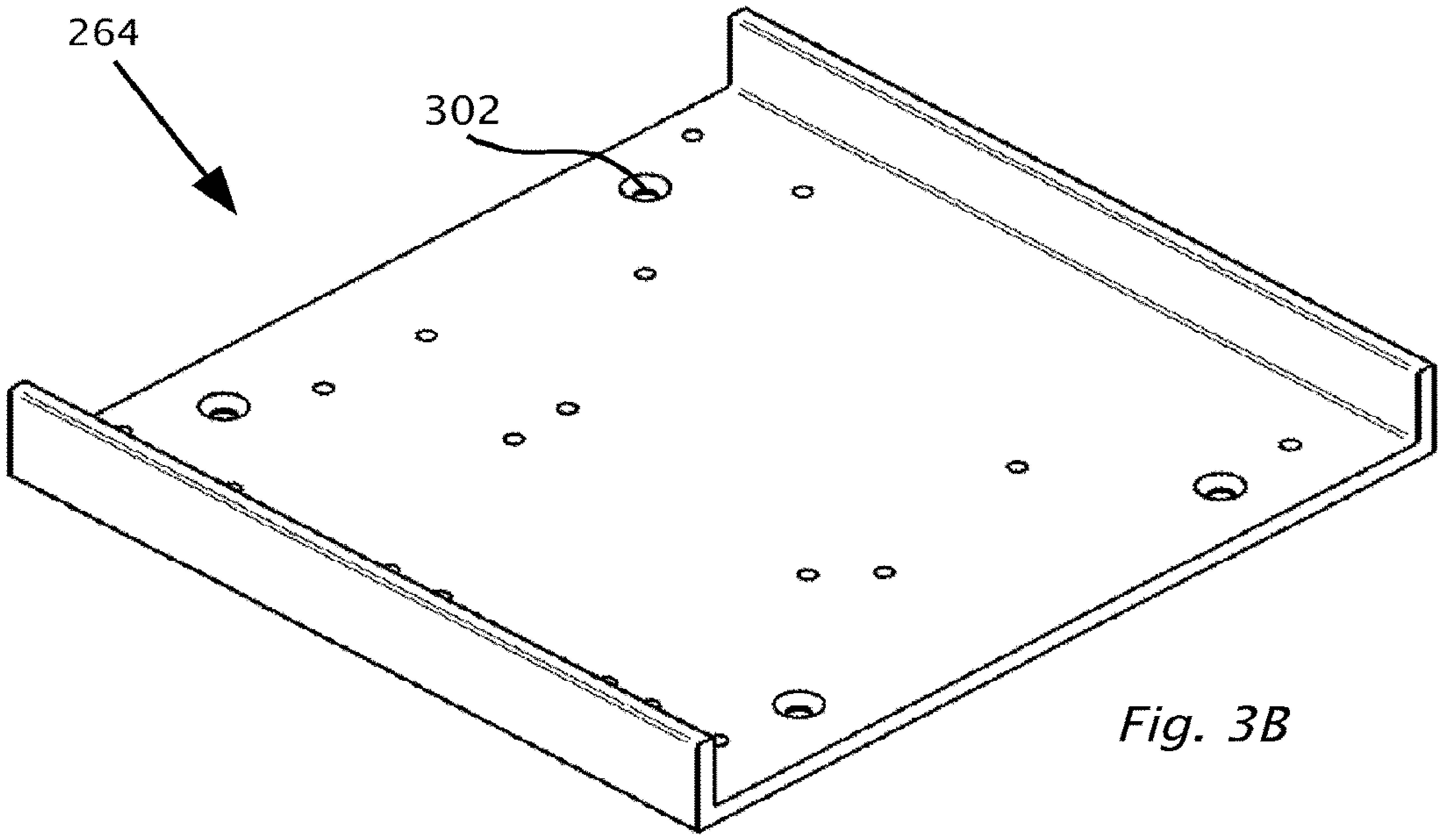


Fig. 3B

ELECTRICALLY ISOLATED HEAT DISSIPATING JUNCTION BOX

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 14/997,079 filed Jan. 15, 2016 (now U.S. Pat. No. 9,748,897 issued on Aug. 29, 2017), which is a continuation of 14/641,690 filed Mar. 9, 2015, (now U.S. Pat. No. 9,748,896 issued on Aug. 29, 2017)which is a continuation of U.S. patent application Ser. No. 13/901,706 filed May 24, 2013 (now U.S. Pat. No. 9,006,569, issued on Apr. 14, 2015), which is a continuation of U.S. patent application Ser. No. 12/785,773 filed May 24, 2010 (now U.S. Pat. No. 8,476,524 issued on Jul. 2, 2013), which claims benefit from U.S. patent application 61/180,455 filed May 22, 2009. The disclosures of the above-identified applications are incorporated herein by reference for all purposes.

BACKGROUND

1. Technical Field

The present invention relates to a junction box for power sources, and specifically to a junction box for electrically connecting to a photovoltaic panel.

2. Description of Related Art

A photovoltaic module or photovoltaic panel is a packaged interconnected assembly of photovoltaic cells, also known as solar cells. Since a single photovoltaic module can only produce a limited amount of power, commercial installations include several modules or panels interconnected in serial and in parallel into a photovoltaic array. Electrical connections are made in series to achieve a desired output voltage and/or in parallel to provide a desired amount of current source capability. A photovoltaic installation typically includes the array of photovoltaic modules, an inverter, batteries and interconnection wiring.

When part of a photovoltaic module is shaded, the shaded cells do not produce as much current as the unshaded cells. Since photovoltaic cells are connected in series, the same amount of current must flow through every serially connected cell. The unshaded cells force the shaded cells to pass more current. The only way the shaded cells can operate at a higher current is to operate in a region of negative voltage that is to cause a net voltage loss to the system. The current times this negative voltage gives the negative power produced by the shaded cells. The shaded cells dissipate power as heat and cause "hot spots". Bypass diodes are therefore integrated with the photovoltaic modules to avoid overheating of cells in case of partial shading of the photovoltaic module.

Blocking diodes may be placed in series with cells or modules to block reverse leakage current backwards through the modules such as to block reverse flow of current from a battery through the module at night or to block reverse flow down damaged modules from parallel-connected modules during the day.

Electronic modules may be integrated with the photovoltaic modules which perform electrical conversion, e.g. direct current (DC) to direct current conversion, electrical inversion, e.g. micro-inverter, or other functions such as monitoring of performance and/or protection against theft.

U.S. Pat. No. 7,291,036 discloses a photovoltaic connection system including a connection box with for surface mounted diodes mounted on a printed circuit board inside of the connection box. The connection box optionally includes a metal plate mounted inside the lid of the connection box as a heat sink for dissipating heat from the diodes.

The term "cable gland" as used herein refers to a device used for the entry of electrical cables or cords into electrical equipment and is used to firmly secure an electrical cable entering a piece of electrical equipment.

The term "in situ" in the context of the present invention refers to bonding or attaching during manufacture, e.g. injection molding, of a part as opposed to attaching after manufacture of the part.

BRIEF SUMMARY

According to an aspect of the present invention there is provided a junction box used for making electrical connections to a photovoltaic panel. The junction box has two chambers including a first chamber and a second chamber and a wall common to and separating both chambers. The wall may be adapted to have an electrical connection therethrough. The two lids are adapted to seal respectively the two chambers. The two lids are configured to be on opposite sides of the junction box relative to the photovoltaic panel. The two lids may be attachable using different sealing processes. One of the lids may be adapted to seal the first chamber and the other lid may seal the second chamber to a different level of hermeticity from that of the first chamber. The first chamber may be adapted to receive a circuit board for electrical power conversion of the power output of the photovoltaic panel. The junction box may include supports for mounting a printed circuit board in the first chamber. The second chamber is configured for electrical connection to the photovoltaic panel. The second chamber may optionally be configured to include diodes, e.g. bypass and/or blocking diodes. The junction box may have electrical connection terminals mounted inside the second chamber for connecting a circuit to the photovoltaic panel. A metal heat sink may be bonded inside the first chamber. The first chamber is adapted to receive a circuit board for electrical power conversion, and the metal heat sink is adapted to dissipate heat generated by the circuit board. The heat sink is placed inside an injection mold during manufacture of the junction box. The junction box may further include a pad adapted to provide thermal conduction and electrical insulation between the circuit board and the metal heat sink. The metal heat sink may include a dovetail structure adapted to prevent mutual separation of the metal heat sink from the junction box. The dovetail structure may be hollow.

According to an aspect of the present invention there is provided a junction box used for making electrical connections to a photovoltaic panel. The junction box has a metal heat sink bonded in situ inside the first chamber. The first chamber is adapted to receive a circuit board for electrical power conversion, and the metal heat sink is adapted to dissipate heat generated by the circuit board. The junction box optionally may have two chambers including a first chamber and a second chamber and a wall common to and separating both chambers. Two lids may be adapted to seal respectively the two chambers. The metal heat sink may include a dovetail structure adapted to prevent mutual separation of the metal heat sink from the junction box. The wall may have an electrical connection therethrough

BRIEF DESCRIPTION OF THE DRAWINGS

Aspects of the invention are herein described, by way of example only, with reference to the accompanying drawings, wherein:

FIGS. **1**A and **1**B illustrate isometric views of a junction box, according to an embodiment of the present invention.

FIG. **2**A shows details of cross section of the junction box indicated by dotted line XX in FIG. **1**A.

FIG. **2**B shows details of cross section YY of the junction box indicated by dotted line in FIG. **1**A.

FIGS. **3**A and **3**B show isometric views of a heat sink according to another embodiment of the present invention.

The foregoing and/or other aspects will become apparent from the following detailed description when considered in conjunction with the accompanying drawing figures.

DETAILED DESCRIPTION

Reference will now be made in detail to embodiments of the present invention, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to the like elements throughout. The embodiments are described below to explain the present invention by referring to the figures.

By way of introduction, diodes and/or electronic modules within junction boxes attached to the photovoltaic modules dissipate heat. When insulating junction boxes are used, heat must be dissipated mostly through air inside the junction box. When metallic junction boxes are used then heat may be dissipated directly through the junction box. However, the use of a metallic junction boxes may be inconvenient because of regulations which require accessible metallic surfaces to be grounded and extra wiring is required.

Before explaining exemplary embodiments of the invention in detail, it is to be understood that the invention is not limited in its application to the details of design and the arrangement of the components set forth in the following description or illustrated in the drawings. The invention is capable of other embodiments or of being practiced or carried out in various ways. Also, it is to be understood that the phraseology and terminology employed herein is for the purpose of description and should not be regarded as limiting.

Referring now to the drawings, FIG. **1**A shows an isometric view **10**A of a junction box **12**, according to an embodiment of the present invention. Junction box **12** is shown mounted on the back (or non-photovoltaic side) **4** of a photovoltaic panel **16**. Junction box **12** has cable glands **130** which allow for termination of cables inside of junction box **12**. Junction box **12** has an outer casing **102** and an access into junction box **12** using a lid **106**.

FIG. **1**B shows an isometric view of the underside of junction box **12** detached from photovoltaic panel **16**. The isometric view shows glands **130** and two sections A and B of junction box **12**. chamber A is bounded by the dimensions Z×X with chamber A covered by lid **108**. Lid **108** gives access into chamber A of junction box **12**. Chamber B is an open section which is bounded by dimensions X×Y and shows terminals **104**. A bypass diode **110** is connected between terminals **104**. According to a feature of the present invention, lid **106** removed to access chamber B and lid **108** used to access chamber A are on opposite sides of junction box **12**.

FIG. **2**A shows details of cross section XX of junction box **12** indicated by dotted line in FIG. **1**A, showing features of the present invention. Cross section XX shows chamber sections A and B of junction box **12** mounted on non-photovoltaic side **4** of photovoltaic panel **16** with clips **216**. The mechanical attachment between junction box **12** and photovoltaic panel **16** using clips **216** is such that junction box **12** is flat on photovoltaic panel **16** and a gasket may be used to seal the open end of chamber B.

Chamber A includes circuit board **260**, thermally conductive pad **262**, heat sink **264**, outer casing **102** and lid **108**. Circuit board **260** is preferably mounted on supports adapted to receive circuit board **260**. Thermal pad **262** provides electrical isolation and thermal conductivity between heat sink **264** and circuit board **260**. The component side of circuit board **260** is preferably in contact with thermal pad **262** so that heat created by the components of circuit board **260** is dissipated by heat sink **264** via thermal pad **262**. Radio Frequency Interference (RFI) emission from junction box **12** as a result of the operation of circuit board **260** is reduced by having the side of lid **108** coated in an electrically conductive shielding **108***a*. Shielding **108***a* connects electrically to heat sink **264** to form a Faraday cage which suppresses RFI emission from junction box **12**.

Lid **108** according to an aspect of the present invention is preferably manufactured by an injection molding process. During the injection molding process of lid **207** a shield **108***a* may be placed in situ and bonded to lid **108** during the injection molding process. Thus, when lid **108** is attached to box chamber A; junction box **12** is electrically isolated by heat sink **264** and shield **108***a*. Outer casing **102** and lid **108** additionally provide a non-electrically conductive isolation of heat sink **264** and shield **108***a* between the backside **4** of panel **16** and the exterior of junction box **12**. Lid **108** is optionally permanently and/or hermetically sealed to chamber A.

Chamber B includes terminal **104**, support **214**, bypass diode **110**, lid **106**, bus bar **212** and wall **202**. Wall **202** provides physical separation between chambers A and B. Electrical connectivity between circuit board **260** in chamber A and electrical connector **104** in chamber B is via bus bar **212**. Bus bar **212** is sealed in wall **202** in such a way as to preserve the desired hermeticity of chamber A for example against the ingress of water or humidity. Both electrical connector **104** and bus bar **212** are supported mechanically by support **214**. Support **214** may also provide hermetic sealing and/or electrical isolation between one end of connector **104** which connects to bus bar **212** and the other end of connector **104** which connects to connections provided by photovoltaic panel **16**. Bypass diode **110** connected to connector **104** may be located between support **214** or backside **4** of panel **16** or between support **214** and lid **106**. Lid **106** gives access to chamber B whilst junction box **12** is physically attached photovoltaic panel **16** but electrically isolated from panel **16**. A preferred mechanism of attaching lid **106** to junction box **12** is to use a rubber gasket arrangement such that chamber B is hermetically sealed against for example the ingress of water/humidity through lid **106** into chamber B.

According to another embodiment of the present invention, junction box **12** is constructed with a wall **202** that may be a double wall so that chamber A and chamber B are mutually separable and re-attachable. Similarly, bus bar **212** is re-connectable between chamber A and chamber B. In this embodiment, a failure within the electronics of circuit board **260** may be repaired by replacing chamber A with a new circuit board **260** without requiring disconnection of chamber B from photovoltaic panel **16**. Similarly, an electronics upgrade may be easily achieved.

Junction box **12** including casing **102**, lids **108**/**106**, heat sink **264**, and thermal pad **262** are preferably adapted to comply with temperature and insulation standard of IEC 61215 (Ed. 2) or other applicable industry standards for use with connection to photovoltaic panels. Junction box **12** and lids **108/106** may be manufactured by injection molding of acrylonitrile butadiene styrene (ABS) thermoplastic, Polybutylene terephthalate (PBT), Poly(p-phenylene oxide) (PPO) or a thermoset such as epoxy resin.

FIG. **2**B shows details of cross section YY of junction box **12** indicated by dotted line in FIG. **1**A, according to an embodiment of the present invention. Cross section YY is of chamber A mounted on backside **4** of photovoltaic panel **16**. Cross section YY shows outer casing **102**, heat sink **264** with dovetail structure **264***a*, thermally conductive pad **262**, circuit board **260** and lid **108** with electrical shield **108***a*.

The manufacture of box chamber sections A and B of junction box **12** in a preferred embodiment of the present invention is by an injection molding process. During the injection molding process heat sink **264** with or without dovetail structure **264***a* is placed inside box chamber A and is bonded in situ to box chamber A as a result of the injection molding process.

Additional strength of the bonding between heat sink **264** and box chamber A may be provided by a dovetail structure **264***a* which may be an integral part of heat sink **264**. A further function of dovetail structure **264***a* ensures that the bonding between heat sink **264** and chamber A remains intact when for example junction box **12** is subjected to thermal stresses as a result of electronic components operating inside chamber A, high ambient heat and sunlight when junction box **12** attached to a photovoltaic panel. Where a fastener, e.g. screw is used to fasten chamber A to heat sink **264**, the lateral dimensions of dovetail structure **264***a* is typically increased in order to accommodate the size of the fastener. A further feature of dovetail structure **264***a* is a hollow structure within dovetail structure **264***a* which allows for a deformation of dovetail structure **264***a*. The deformation of dovetail structure **264***a* allows for the different rates of thermal expansion of enclosure **102** and heat sink **264**/dovetail structure **264***a* during the curing/cooling of the bond between heat sink **264** and enclosure **102** of chamber A.

Reference is now made to FIGS. **3**A and **3**B which show isometric views of heat sink **264** according to another embodiment of the present invention. Heat sink **264** has four holes **302**. Holes **302** are used to attach heat sink **264** into chamber A of junction box **12** using screws. The attachment of heat sink to chamber A may come as an additional step after the injection molding of junction box **12** or of a junction box **12** which is not injection molded. An additional thermal pad may be placed between heat sink **264** and enclosure **102** to ensure good contact between heat sink **264** and enclosure **102** after heat sink **264** is attached enclosure **102**. The deformable nature of the thermal pad used to accommodate non-uniformity in surfaces of the heat sink **264** and enclosure **102** due to manufacturing tolerances of heat sink **264**/enclosure **102**. Alternatively a thermally conducting glue or potting material may be placed between heat sink **264** and enclosure **102**.

The articles "a" "an" as used herein mean "one or more" such as "a heat-sink", "a circuit board" have the meaning of "one or more" that is "one or more heat-sinks" or "one or more circuit boards".

Although selected embodiments of the present invention have been shown and described, it is to be understood the present invention is not limited to the described embodiments. Instead, it is to be appreciated that changes may be made to these embodiments without departing from the principles and spirit of the invention, the scope of which is defined by the claims and the equivalents thereof.

The invention claimed is:

1. A junction box comprising:

a first chamber sealed against a first level of water ingress by a first lid;

a second chamber sealed against a second level of water ingress by a second lid, the first level of water ingress being different than the second level of water ingress;

a circuit board within the first chamber and designed to convert electrical power received from a photovoltaic panel; and

an electrical connection within the second chamber and designed to receive the electrical power from the photovoltaic panel.

2. The junction box of claim **1**, wherein the first lid and the second lid are configured to be on opposite sides of the junction box relative to the photovoltaic panel.

3. The junction box of claim **1**, further comprising a metal heat sink bonded inside the first chamber, the metal heat sink configured to dissipate heat generated by the circuit board.

4. The junction box of claim **3**, wherein the metal heat sink comprises a structure adapted to prevent mutual separation of the metal heat sink from the junction box.

5. The junction box of claim **1**, further comprising a wall to separate the first chamber and the second chamber, wherein the wall allows for mutual separation and reattachment of the first chamber and second chamber.

6. The junction box of claim **1**, wherein a side of the second chamber is configured to attach to the photovoltaic panel, and wherein the first chamber is configured to disconnect from the photovoltaic panel without disconnecting the second chamber from the photovoltaic panel.

7. The junction box of claim **1**, further comprising a re-connectable second electrical connection that connects the circuit board in the first chamber to the electrical connection in the second chamber.

8. The junction box of claim **1**, further comprising a gasket configured to seal an open end of the second chamber.

9. A junction box comprising:

a first chamber comprising a circuit board designed to convert electrical power received from a photovoltaic panel;

a second chamber designed to receive the electrical power from the photovoltaic panel,

wherein the first chamber is sealed against a first level of water ingress by a first lid separately from the second chamber,

wherein the second chamber is sealed against a second level of water ingress by a second lid, and

wherein the first level of water ingress is different that the second level of water ingress.

10. The junction box of claim **9**, wherein the first lid and the second lid are configured to be on opposite sides of the junction box relative to the photovoltaic panel.

11. The junction box of claim **9**, further comprising a metal heat sink bonded inside the first chamber, the metal heat sink configured to dissipate heat generated by the circuit board.

12. The junction box of claim **11**, wherein the metal heat sink comprises a structure adapted to prevent mutual separation of the metal heat sink from the junction box.

13. The junction box of claim **9**, further comprising:

a wall to separate the first chamber and the second chamber, wherein the wall allows for mutual separation and reattachment of the first chamber and second chamber.

14. The junction box of claim **9**, wherein the first chamber is configured to disconnect from the photovoltaic panel without disconnecting the second chamber from the photovoltaic panel.

15. A method comprising:

sealing, in a junction box, a first chamber against a first level of water ingress by a first lid;

sealing, in the junction box, a second chamber against a second level of water ingress by a second lid, wherein the first level of water ingress is different than the second level of water ingress;

configuring an electrical connection within the second chamber to receive electrical power from a photovoltaic panel; and

configuring a circuit board within the first chamber to receive power from the photovoltaic panel via the electrical connection of the second chamber.

16. The method of claim **15**, further comprising

configuring a wall to separate the first chamber and the second chamber, wherein the wall allows for mutual separation and reattachment of the first chamber and second; and

configuring the first chamber to disconnect from the second chamber and the photovoltaic panel without disconnecting the second chamber from the photovoltaic panel.

17. The method of claim **15**, further comprising;

configuring the first lid and the second lid to be on opposite sides of the junction box relative to the photovoltaic panel.

18. The method of claim **15**, further comprising;

bonding a metal sink inside the first chamber, the metal sink comprising a structure adapted to prevent mutual separation of the metal heat sink from the junction box; and

configuring the metal sink to dissipate heat generated by the circuit board.

* * * * *